P-9.1 Predict the behavior of fluids (including changing forces) in pneumatic and hydraulic systems.

Revised Taxonomy Level 2.5B Infer (predict) conceptual knowledge
Students did not address this indicator in physical science

It is essential for students to

- Understand that the term fluid applies to both liquids and gases because of the properties and behaviors that are common to both
  - Pneumatic systems involve gases
  - Hydraulic systems involve liquids
- Understand the properties of fluids
  - Buoyant force
  - Streamline flow
- Compare how open and closed fluid systems are different

Assessment

As the verb for this indicator is Infer (predict)**,** therefore, the major focus of assessment should be for students to draw a logical conclusion from presented information. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students understand how the behavior of fluids depends on the properties of buoyant force and streamline flow. Students should be able to use these properties to predict the behavior of fluids in familiar situations.

P-9.2 Apply appropriate procedures to solve problems involving pressure, force, volume, and area

Revised Taxonomy Level 3.2 C_A Apply procedural knowledge
Students did not address this indicator in physical science

It is essential for all students to

- Understand that pressure is the force applied per unit area, P = F/A
- Understand that pressure is measured in units of Pascal's in the metric system (N/m^2)
- Explain the difference between absolute and gage pressure
- Use the formula $P=P_0 + \rho gh$
- Where
  - P = pressure
  - P_0 = original pressure
  - ρ = density
  - g = acceleration of gravity
  - h = depth

- Use the formula P = F/A
- Where
  - P = pressure
  - F = force
  - A = area

Assessment
The revised taxonomy verb for this indicator, apply, means that the major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator, procedural knowledge means "knowledge of subject-specific techniques and methods" In this case the procedure for solving problems involving pressure. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of fluids and pressure, volume and area

P-9.3 Explain the factors that affect buoyancy.

Revised Taxonomy Levels 2.7 B Explain conceptual knowledge

Students did not address this indicator in Physical science

It is essential for all students to

- Use the formula $F_{buoy} = \rho Vg$
  - Where
    - F_{buoy} = the buoyant force
    - ρ = density
    - V = volume
    - g = acceleration of gravity
- Discuss how each of the variables above affect the buoyancy of an object.

Assessment

The verb, explain means that the major focus of assessment should be for students to "construct a cause and effect model". In this case, assessments will ensure that students can model how the buoyant force is affected by each of the given variables. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students can construct a cause and effect statement relating how each of the variables, density, volume, and acceleration of gravity affect the buoyant force on an object.

P-9.4 Explain how the rate of flow of a fluid is affected by the size of the pipe, friction, and the viscosity of the fluid

Revised Taxonomy Levels 2.7 B Explain conceptual knowledge

In physical science, students were introduced to viscosity as a physical property of a fluid and they studied friction as an opposing force for moving objects.

It is essential for students to

- Understand that the flow rate can be measured several ways
  - Volumetric flow rate (ft^3/sec), (gal/min), (l/sec), (m^3/sec)
    - The volume of fluid flowing past a given point in a fluid flow system per unit of time
  - Mass flow rate, (lb/sec) or (kg/sec)
    - The amount of fluid mass flowing past a given point in a fluid flow system per unit of time
- Understand that the flow rate is directly proportional to the square of the diameter of the pipe.
- Understand that friction has a negative affect on the flow rate of a fluid system in two ways
  - Because of the friction of a fluid in contact with a pipe, the flow rate of the fluid is slower near the walls of the pipe than at the center.
  - The smoother, cleaner, and larger a pipe is, the less effect pipe friction has on the overall flow rate
  - Compare laminar and turbulent flow
  - Explain why a freely falling object has terminal speed
- Understand that the viscosity of a flowing fluid is a direct indication of the work which must be done to maintain that fluid in steady flow, so the higher the viscosity of the liquid, the lower the flow rate.
  - Identify the normal laboratory method of measuring viscosity

Assessment

The verb, explain means that the major focus of assessment should be for students to "construct a cause and effect model". In this case, assessments will ensure that students can model how pipe diameter, friction, and viscosity of the liquid affect its flow rate. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students can construct a cause and effect statement relating each of these factors affect the flow rate in a given fluid system.

P-9.5 Explain how depth and fluid density affect pressure.

Revised Taxonomy Levels 2.7 B Explain conceptual knowledge

Students did not address this concept in physical science

It is essential for students to

- Understand and use the equation $P = \rho gh$
  - Where
    - P = pressure
    - ρ = density of the fluid
    - g = acceleration of gravity
    - h = depth of the fluid
- Understand that the pressure of a fluid does not depend on
  - the shape of the container
  - The volume of the fluid
  - the total weight of the fluid
- Understand that at any point within a fluid, the forces that produce pressure are exerted equally in all directions

Assessment

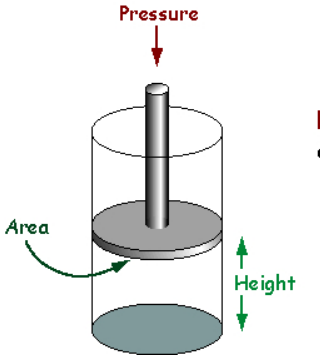
The verb, explain means that the major focus of assessment should be for students to "construct a cause and effect model". In this case, assessments will ensure that students can model the factors that affect the pressure of a fluid. Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments must show that students can construct a cause and effect statement relating how each factor, density and depth, affect the pressure of a fluid, as well as the factors which do not affect the density of a fluid.

P-9.6 Apply fluid formulas to solve problems involving work and power.

Revised Taxonomy Level 3.2 C_A <u>Apply</u> procedural knowledge

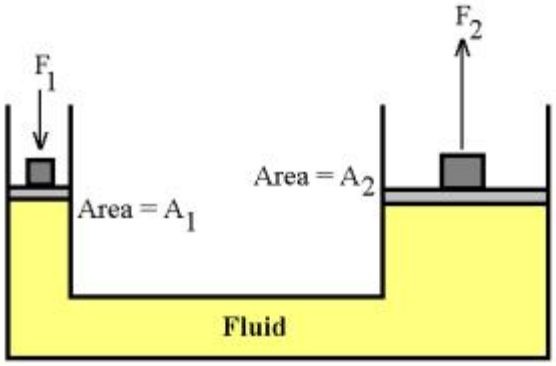
Students did not address power in physical science
It is essential for students to

- Understand that power is the rate of work so P = p x ΔV/t
- Understand that a common type of work is the work done by a gas through expansion or the work done to a gas through compression.



  - Pressure is the force applied per unit area, P = F/A
  - Pressure is measured in units of Pascals in the metric system (N/m^2)
  - Work is defined as Force applied over a distance so the work done by the fluid on the piston or the work done by the piston on the fluid is the force applied over the change in height of the gas chamber
    W = F x Δh where $\Delta h = h_f - h_i$
  - Therefore for a piston the work associated with moving a distance Δh can be found with the equation W = p x A x Δh
  - A x Δh is equal to the change in volume of the cylinder so W = p x ΔV
  - If ΔV is positive then the gas is expanding and doing work on the surroundings. So work should be negative W = -p x ΔV
- Understand and apply Pascal's Principle to hydraulic systems
  - "When there is an increase in pressure at any point in a confined fluid, there is an equal increase at every other point in the container."
  - Because the pressure throughout the fluid is equal to force x area

- In the diagram below, $F_1 \times A_1 = F_2 \times A_2$



- Pascal's law allows forces to be multiplied. The cylinder on the left shows a small cross-section area of 1 square meter, while the cylinder on the right shows a large cross-section area of 10 square meters. The cylinder on the left has a weight of one Newton acting downward on the piston, which lowers the fluid 10 meters. As a result of this force, the piston on the right lifts a 10 Newton weight a distance of 1 meter
- The 1 Newton load on the 1 square meter area causes an increase in pressure on the fluid in the system.
- This pressure is distributed equally throughout and acts on every square meter of the 10 square meter area of the large piston. $1N/m^2 \times 10m^2$ gives a force of 10 N on the right
- As a result, the larger piston lifts up a 10 Newton weight. The larger the cross-section area of the second piston, the larger the mechanical advantage, and the more weight it lifts.
- The following formulas are related to a hydraulic lift
  - $P_1 = P_2$ (since the pressures are equal throughout)
  - $F_1/A_1 = F_2/A_2$ (Since pressure equals force per unit area)
  - $V_1 = V_2$ (Because the volume of fluid pushed down on the left side equals the volume of fluid that is lifted up on the right side)
  - $A_1D_1 = A_2D_2$ where
    - A = cross sectional area
    - D = the distance moved

Assessment

The revised taxonomy verb for this indicator is implement (apply), the major focus of assessment will be for students to show that they can "apply a procedure to an unfamiliar task". The knowledge dimension of the indicator, procedural knowledge means "knowledge of subject-specific techniques and methods" In this case the procedure for solving problems relating to power and work in fluid systems. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of fluid mechanics.